United States
Department of
Agriculture

Forest
Service

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Management**

**Methods
Application
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PANORAMIC AERIAL PHOTOGRAPHY FOR DETECTION OF OAK DECLINE AND MORTALITY IN CENTRAL TEXAS

Report No. 85-1

3400
December 1984

PANORAMIC AERIAL PHOTOGRAPHY FOR DETECTION OF OAK DECLINE AND MORTALITY IN CENTRAL TEXAS

by

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ABSTRACT

Small scale color infrared (CIR) panoramic aerial photos (ca. 1:32,500) were evaluated to detect centers of decline and mortality in Texas live oak stands in central Texas. Results of monoscopic photo interpretation on panoramic photos was compared to photo interpretation of the same areas on ca. 1:12,000 scale conventional 9-inch CIR aerial photos using a geographic information system. Area of agreement, the common area classified as oak decline and mortality on both films, was relatively low, only 20 percent of the total area classified on each film. Sources of disagreement are discussed.

This work suggests that panoramic aerial photography, when viewed monoscopically, is a promising method for mapping groups of dead trees, but it is not capable of consistently resolving trees with early symptoms of stress and decline.

INTRODUCTION

Decline and mortality of Texas live oak, Quercus virginiana var. fusiformis[2] (Small) Sarg. has been reported in central Texas since 1934 (Dunlap and Harrison 1949). Two vascular wilt fungi have been cited as causal agents. One is Cephalosporium diospyri Crandell, which causes a slow

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[2] Scientific names of trees used in this paper are according to Little, 1979.

progressive disease called live oak decline (Halliwell 1966; Van Arsdel 1978). More recently, oak wilt, a vascular disease caused by the fungus Ceratocystis fagacearum (Bretz) Hunt, has been linked to the decline and mortality (Lewis 1977). This condition has received considerable public interest in recent years because it is causing extensive damage to Texas live oak and other oaks in both urban and forested environments throughout much of central Texas. Texas live oak is one of the most abundant trees in this area.

The pattern of spread of oak wilt is different in central Texas than other areas where this disease occurs, primarily due to the biology of its principle host. Stands of Texas live oak commonly reproduce by sprouting from a common root system (Billings, et al. 1982); therefore, when a single stem becomes infected with oak wilt, the fungus can spread rapidly to other stems via the common root system. This can cause extensive areas of tree decline and mortality. Oak wilt in Texas live oak causes a gradual dieback and decline over several years followed by eventual tree mortality (Fig. 1). This is in contrast to the rapid mortality over much of the eastern United States characteristic of trees of the red oak group (Rexrode and Brown 1983).

Personnel of the Texas Forest Service, Texas A&M University, and USDA Forest Service, Southern Region, have used medium scale (1:12,000) 9-inch color-infrared (CIR) aerial photos to detect and map the location of tree decline and mortality in central Texas (Billings et al. 1982). While medium scale CIR aerial photos are effective for mapping oak decline and mortality, acquisition cost is high and effective area coverage for a single photo is relatively small. This makes the cost of this photo product prohibitive for mapping vegetation damage over extensive areas.

Panoramic aerial photography, taken with high altitude reconnaissance aircraft has proven to be an effective alternative for mapping vegetation damage caused by several forest insects (Ciesla and Acciavatti 1982; Caylor et al. 1982; Klein 1982; Dillman and White 1982). This approach might be advantageous for mapping oak mortality and decline because of the ability of this system to cover large areas of land in a relatively short time and produce high resolution aerial photos (Ciesla et al. 1982). This report describes the results of an evaluation of panoramic aerial photography for detection of decline and mortality in oak forests of central Texas.

METHODS

DESCRIPTION OF TARGET SITE

The target sites for this evaluation included portions of Bandera, Kerr, Travis, and Williamson Counties in south central Texas. This region is commonly known as the Texas Hill Country. It consists of a deeply dissected limestone plateau which rises from the Gulf Coastal Plain to elevations ranging from 1,000-2,800 feet above sea level, and is characterized by a series of limestone bluffs, rolling terrain, flat topped hills, and clear, spring fed streams. Annual precipitation is 28-30 inches (Douglas 1967; Hanson 1969).

Figure 1 - Texas live oak killed by oak wilt in central Texas.

Vegetation cover consists of several distinct plant associations. Extensive stands of open grown Texas live oak with occasional Texas red oak, _Q. shumardii_ var. _texana_ (Buckl.) Ashe; post oak, _Q. stellata_ Wangenh.; blackjack oak, _Q. marilandica_ Muenchh.; and mesquite, _Prosopis sp._, occupy the valley floors and level summits of the limestone hills. Pure stands of Ashe juniper, _Juniperus ashei_ Bucholz, also cover large areas.

Deciduous hardwoods occupy the steeper terrain and often occur in concentric bands on the slopes of the limestone hills. These consist of the above mentioned deciduous oaks as well as vasey (Shin) oak, _Q. pungens_ var _vaseyana_ (Buckl.) C.H. Muller; Lacy oak, _Q. glaucoides_ Maet. & Gal.; and other hardwoods. Minor plant associations include bands of bald cypress, _Taxodium distichum_ (L.) Rich.; and Texas walnut, _Juglans microcarpa_ Berland, along the river bottoms.

Ranching and recreation are the predominant land uses in the area. The Texas Hill Country is a favorite for summer camps, summer homes, church camps, health resorts and hunting lodges. A variety of native game species occur in abundance including white tailed deer, jack rabbits, doves, and wild turkey. Several ranches in the area import exotic game species from Europe, Asia, and Africa for sport hunting (Hanson 1969).

Oak decline and mortality has severely affected the areas resource values. This is especially true where Texas live oak was retained as a natural landscape material in subdivision or recreation area developments. In addition, the oak forests provide cover and mast for the many game species which occur here.

PHOTO ACQUISITION AND INTERPRETATION

Panoramic aerial photography was taken over the central Texas target site on May 16, 1983, by a NASA Lockheed ER-2[3/] reconnaissance aircraft based at the NASA Ames Research Center, Moffett Field, California, (NASA Mission 83-081). An Itek Iris II panoramic aerial camera with a 140° field of view and Kodak SO-131 color infrared (CIR) film were used. Nadir photo scale was ca. 1:32,000. Film format was 5.5 by 59.5 inches.

Mission 83-081 consisted of three flight lines over the target site as follows (Fig. 2):

Flight Line	Area Covered	Direction	No. Frames
C-D	Fredericksburg/Johnson City	E-W	18
E-F	Kerrville Bandera	N-S	21
G-H	Austin	N-S	19

Interpreted data from the panoramic photos was compared with the interpretation of conventional 9-inch frame photography taken over the target site by the Texas Forest Service during August 1982 (Billings et al. 1982). This photography was taken with a Zeiss 15/23 RMK aerial camera by the Texas Forest Service. Photo scale was Ca. 1:12,000. Film was Kodak Aerochrome Infrared type 2443. Interpretation of this film was done under the supervision of Dr. Robert Maggio, Department of Forest Science, Texas A&M University, College Station, Texas.

Photo interpretation of the 9-inch photography of flight line C-D by Texas A&M University showed a low incidence of tree decline and mortality (Maggio, personal communication). Therefore, only flight lines E-F and G-H of the panoramic photo mission were interpreted.

[3/] Mention of commercial products is for convenience only and does not imply endorsement by the USDA.

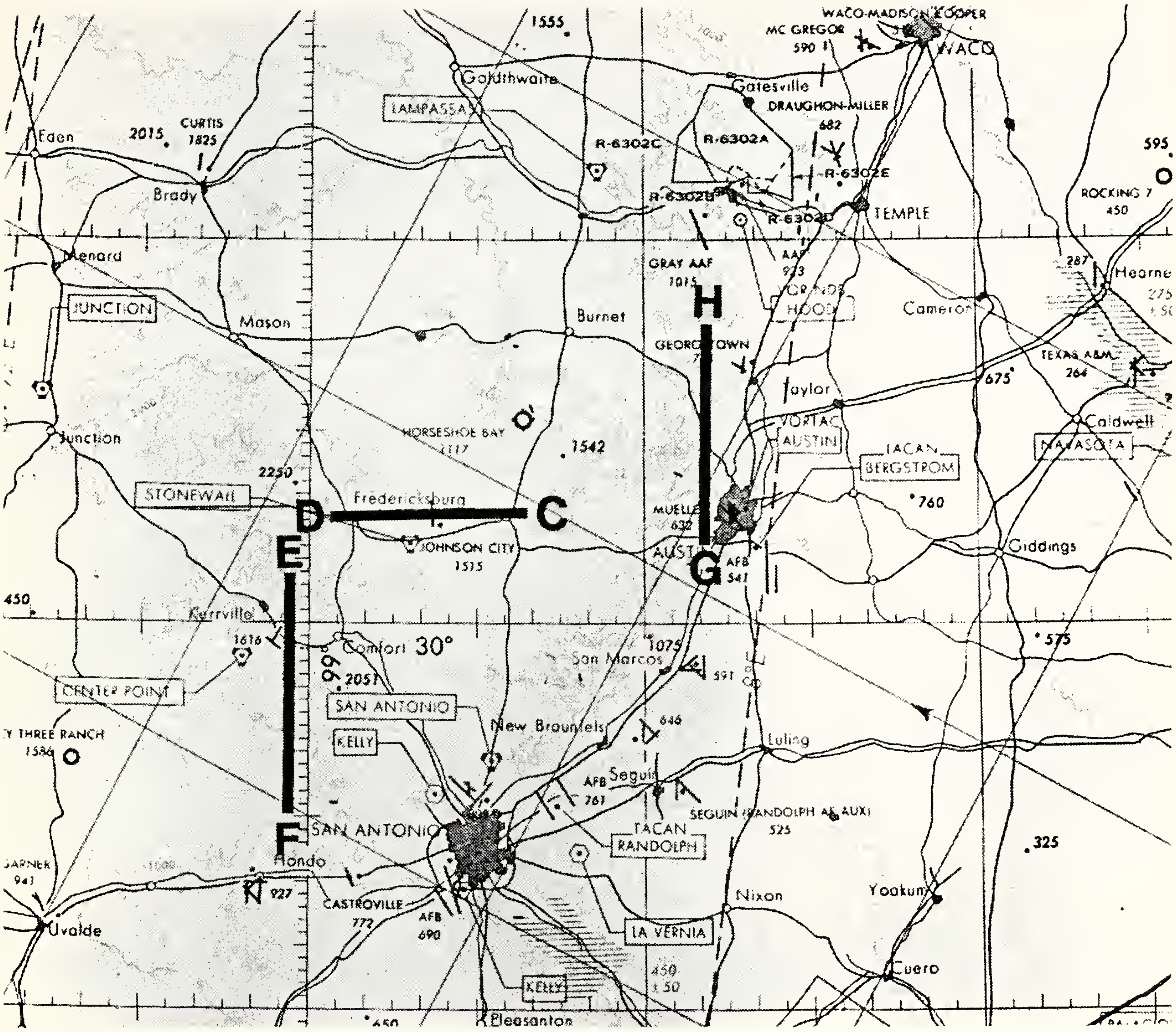

Figure 2 - Flight path of NASA Mission 83-081 over central Texas.

Preliminary viewing, analysis, and ground checking of the panoramic aerial photography was done prior to formal photo interpretation to confirm the appearance of tree decline and mortality and develop PI procedures.

Interpretation of the panoramic photography was done at the facilities of the USDA Forest Service, Nationwide Forestry Applications Program, Houston, Texas. Alternate photos were examined on a Richards light table with a Bausch and Lomb Zoom 240 stereoscope in monoscopic mode (Fig. 3). Only that portion of each photo which fell within ±40° of nadir and was covered by the 9-inch photos was interpreted. A clear plastic equal area PANGRID overlay (Liston 1982) with 40 acre grid cells was taped to the light table and photo frames were registered over the grid. Interpreters systematically examined each grid under a magnification at which a single 40 acre cell filled the field of view.

Figure 3 - Photo interpreter classifying areas of oak decline and mortality on panoramic CIR aerial film.

Delineation of groups of symptomatic trees was done to the same standard as was done on the frame photography. Groups of dead, dying, and declining trees were outlined as polygons directly on the photos with an indelible marking pen (Pilot ultra fine point SC-UF). These polygons were transferred to 7-1/2 minute USGS topographic maps (scale=1:24,000) using a Bausch and Lomb Zoom Transfer Scope.

DATA ANALYSIS - A geographic information system was used to compare the photo interpretation results from the two aerial photographic data sets. Polygons transferred to the 7-1/2 minute USGS topographic maps were digitized from both the panoramic and 9-inch aerial photo sets. The Map Overlay and Statistical System (MOSS), developed by the U.S. Fish and Wildlife Service, was utilized on the Resource Evaluation and Monitoring Integrated Data Analysis System (REMIDAS) at the USDA Forest Service, Southern Region Forest Pest Management Aerial Survey Team located at Doraville, Georgia. REMIDAS is based on a Data General Eclipse S/250 minicomputer with an integral array processor. The MOSS

component of REMIDAS is interfaced to the digitizing subsystem, which in turn, can also be interfaced to a color display system as well as providing hard copy of the display to a printer/plotter and matrix camera.

A version of MOSS had been modified to interact with other REMIDAS software and hardware. It served as a software link between a digitizing subsystem and the gridded geographic data base analysis subsystem by accepting digitized polygon output from the first and producing gridded data output products which are suitable for processing by the second.

The polygons for each map were converted into a cell grid with a 25 meter cell size. Each overlay was then coded as determined from the photo interpretation results. Four different data layers were digitized, processed into individual polygon data layers, and then processed into a 25 meter cell grid. These four data layers were: (1) the map boundaries of each of the 7-1/2 minute map sheets; (2) the boundary of the 9 x 9 aerial photo coverage area; (3) the polygons delineated from optical bar photo interpretation; and, (4) the polygons delineated from 9 x 9 aerial photographic interpretation. Each geographic data base file consisted of one grid variable (layers of grid cells) covering the same geographic area. Each grid variable represents a single layer of data for the geographic area covered by the grid. The map boundary, 9-inch frame photography coverage limits, and 9-inch frame photography delineated oak mortality data layers were combined using the gridded data base overlay function. This new data layer was combined with the panoramic photography delineated oak mortality data layer using a matrix (cross tabulation) data base function to create a final data layer in which individual data values represented areas of agreement and errors of omission and commission in the photo interpretation.

RESULTS

QUALITY OF PANORAMIC PHOTOGRAPHY - Photo quality was generally good, however, variations in exposure occurred across the film. This may be due to low sun angle since the mission was flown during the early morning (9:30-10:30 a.m. local time). Exposure variations were especially conspicuous on flight line E-F (Table 1).

Table 1 - Exposure variations on frames of panoramic aerial photography of central Texas. (NASA mission 83-081).

Photo Segment	Exposure
70° W - 10° W	Overexposed by 1/2 to 1 F stop
10° W - Nadir	Optimum
Nadir - 25° E	Optimum
25° E - 35° E	Underexposed by 1 F stop
35° E - 70° E	Optimum to slightly overexposed

APPEARANCE OF VEGETATION COMMUNITIES AND DAMAGE

Deciduous hardwoods were fully foliated at the time of photo acquisition. Vegetation communities were recognized on the basis of crown shape, color, and topographic position. Three major vegetation communities could be recognized (Fig. 4):

Deciduous Hardwoods - Crown shape is broad and rounded. Crown color on SO-131 color-IR film is purplish pink to purplish red. This community occurs in dense stands on the steeper slopes and canyons often in distinct bands which follow contour lines.

Ashe Juniper - Crown shape is small and conical, crown color is grey violet to grey blue. This vegetation community occurs in relatively pure stands primarily along the lower slopes of the hills.

Texas Live Oak - Crown shape and color are similar to the deciduous hardwoods. This community can be separated from the deciduous hardwoods because of its characteristic open grown nature and its occurrence on relatively level terrain in valley bottoms or the flat topped summit of the hills.

Dead and declining hardwoods characteristically appeared as groups of open grown crowns purplish blue to blue grey in color (Fig. 5). Bare branches were distinctly visible throughout all or a portion of the crown.

During preliminary examination of several frames of panoramic aerial photography near Kerrville and Bandera, 21 groups of trees suspected of being dead and declining Texas live oak were located and ground checked. Twenty of the 21 groups were, in fact, centers of oak decline and mortality. The area that was misidentified was a group of open grown Ashe juniper.

Variations in exposure across the photo frame caused slight changes in the color of the vegetation communities and the dead and declining trees (Table 2).

COMPARISON OF PANORAMIC WITH FRAME PHOTOGRAPHY - Color REMIDAS displays of polygon overlays effectively showed the results obtained from the 9-inch and panoramic aerial photography (Figs. 6, 7).

Proportion of area classified as tree decline and mortality on both 9-inch and panoramic photos, the area of agreement, was low. Twenty percent of the total area classified as tree decline and mortality was classified on both films. A considerable area was classified either only on the 9-inch photos or the panoramic photos (Tables 3, 4).

Side-by-side re-examination of selected 9-inch photos with corresponding frames of panoramic photos showed that photo interpreters, working with the 9-inch photos, tended to draw larger polygons (Table 3, Fig. 7). The overlay of the two sets of photo interpretation showed that photo interpreters,

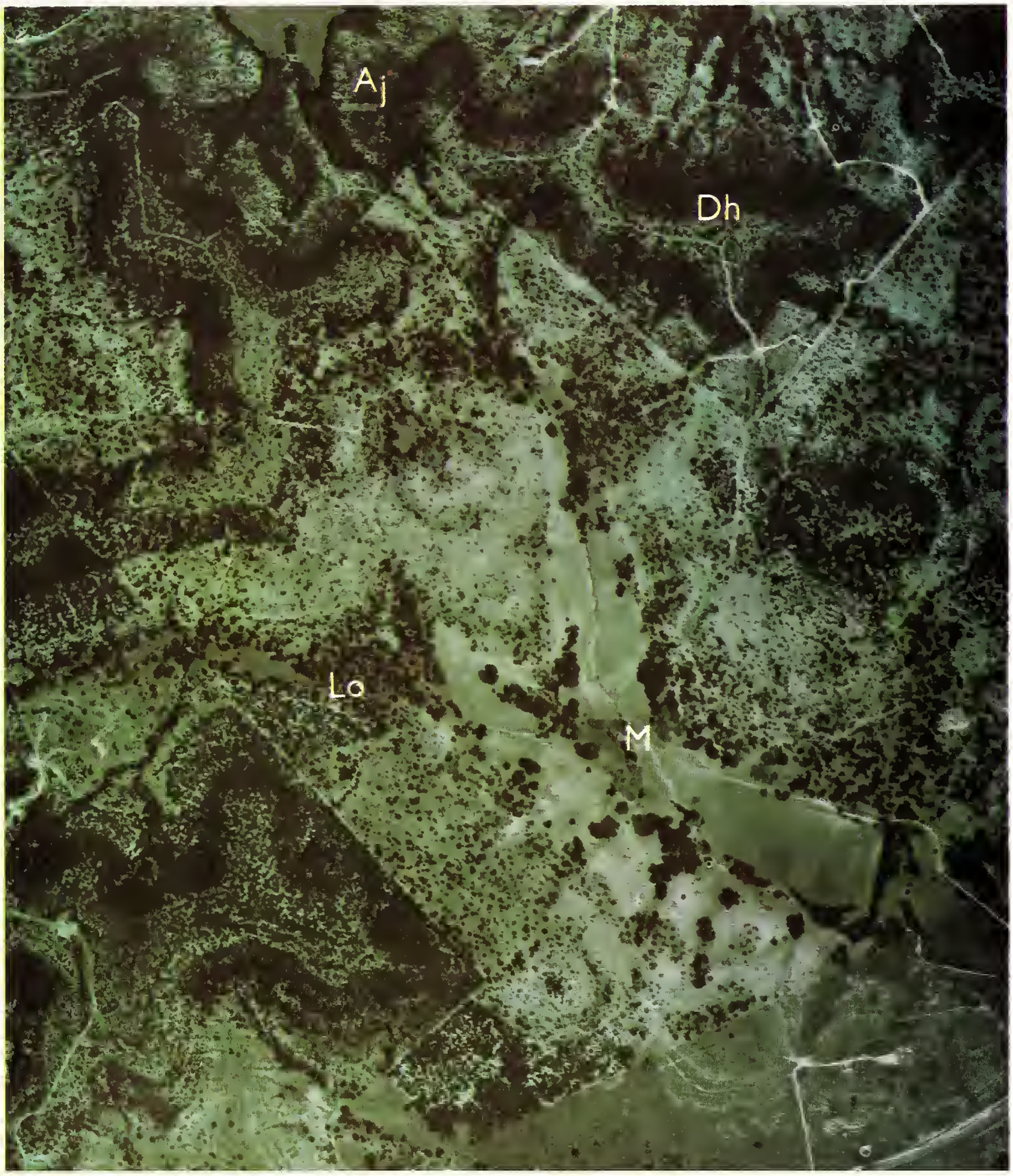

Figure 4 - Vegetation communities in central Texas as they appear on CIR panoramic aerial film; Deciduous hardwoods (Dh) occur in distinct bands of dense stands on the steeper hillsides. Ashe juniper (Aj) occurs in relatively pure stands of small crowned trees, grey violet to grey blue in color. Live oak stands (Lo) are open grown and occur in the valley bottoms or summits of the hills. A group of dead and declining oaks appears at M (2X enlargement, original photo scale - 1:32,500).

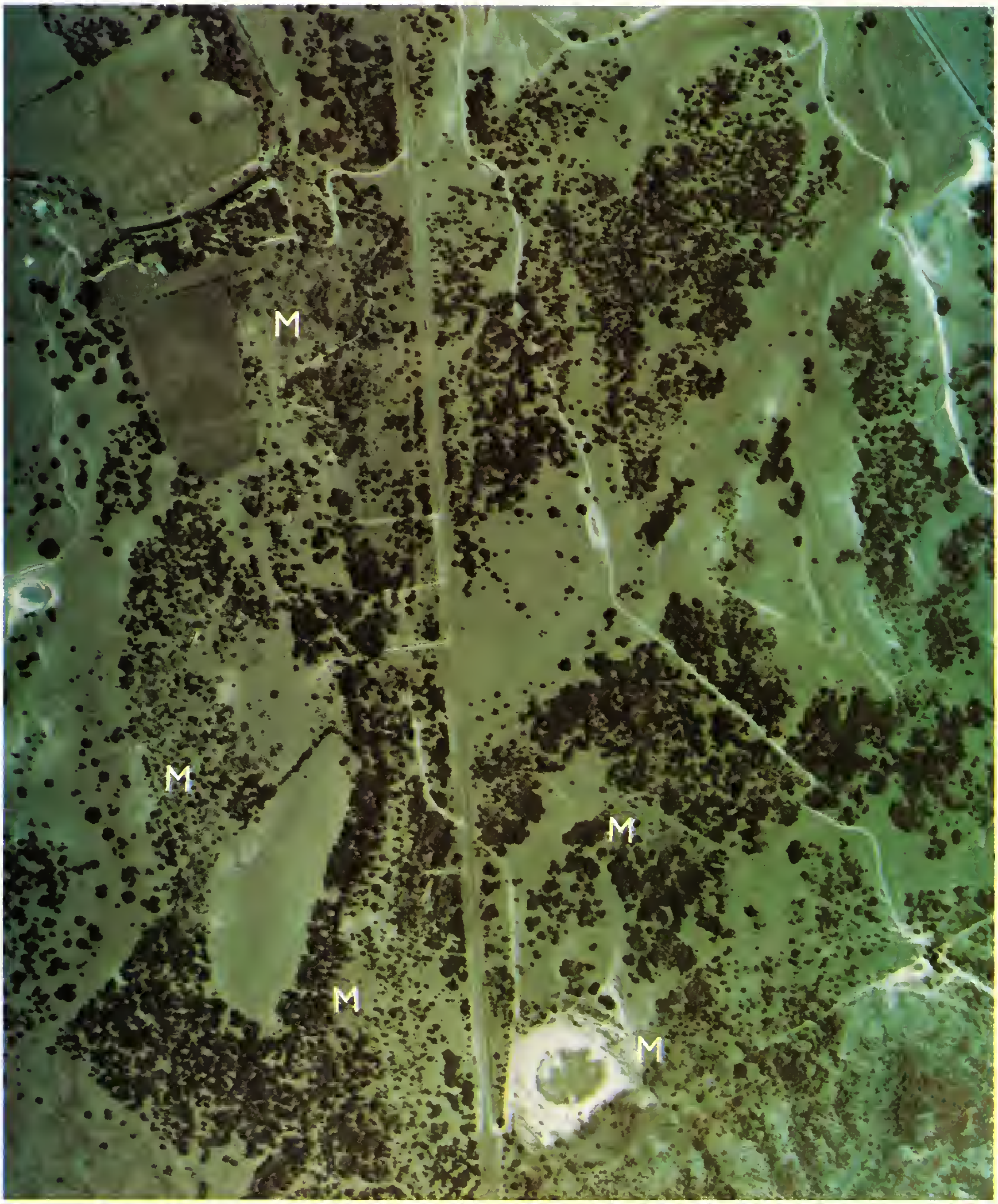

Figure 5 - Groups of dead and declining Texas live oaks south of Bandera, Texas, appear at M. These groups were ground checked and confirmed to be oak decline and mortality. Light colored area at lower right is a sanitary land fill (2X enlargement, original photo scale - 1:32,500).

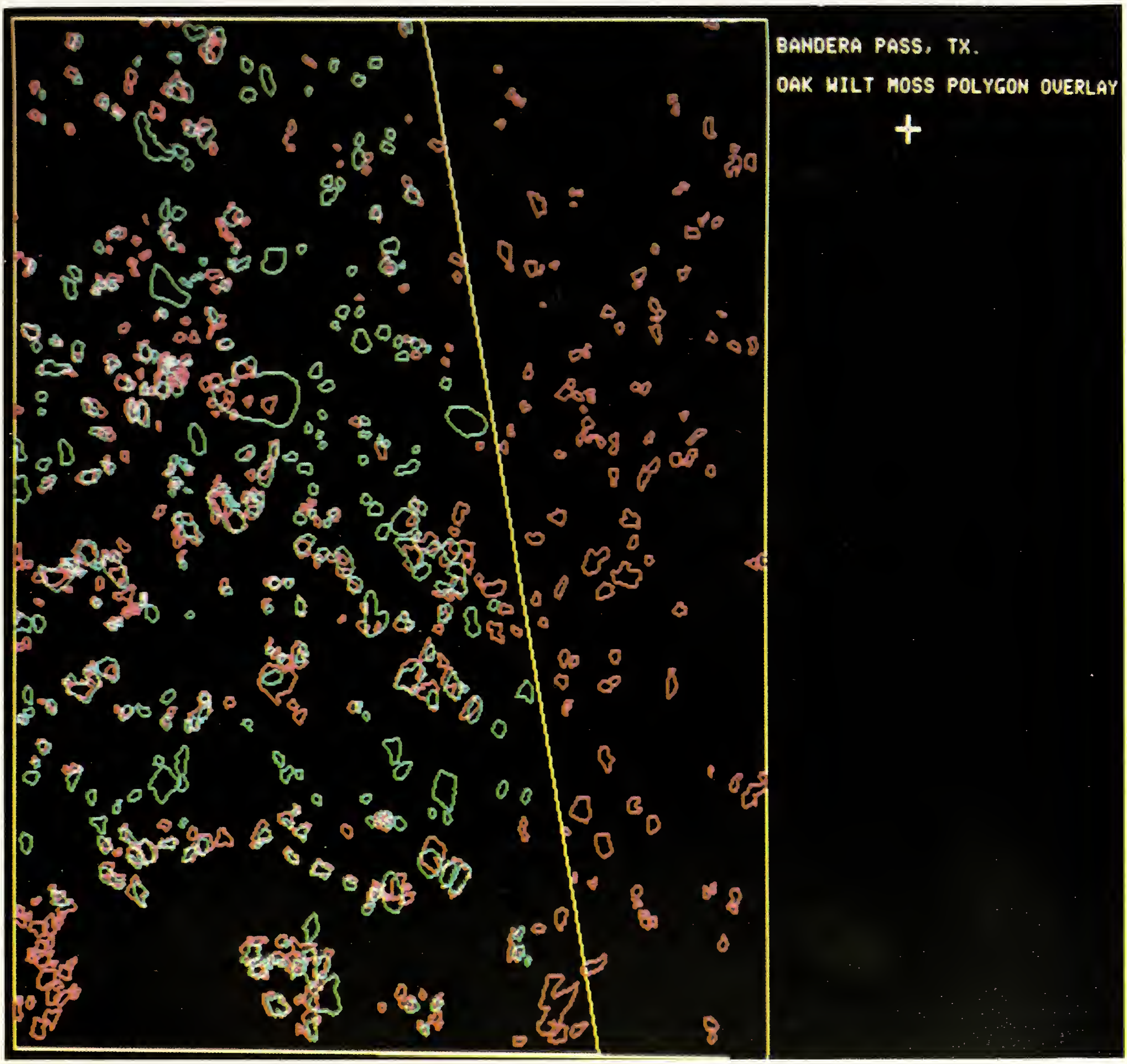

Figure 6 - REMIDAS color display of the Bandera Pass $7\frac{1}{2}$ minute quadrangle showing polygons of oak decline and mortality classified on 9-inch photos (cyan) and panoramic photos (magenta).

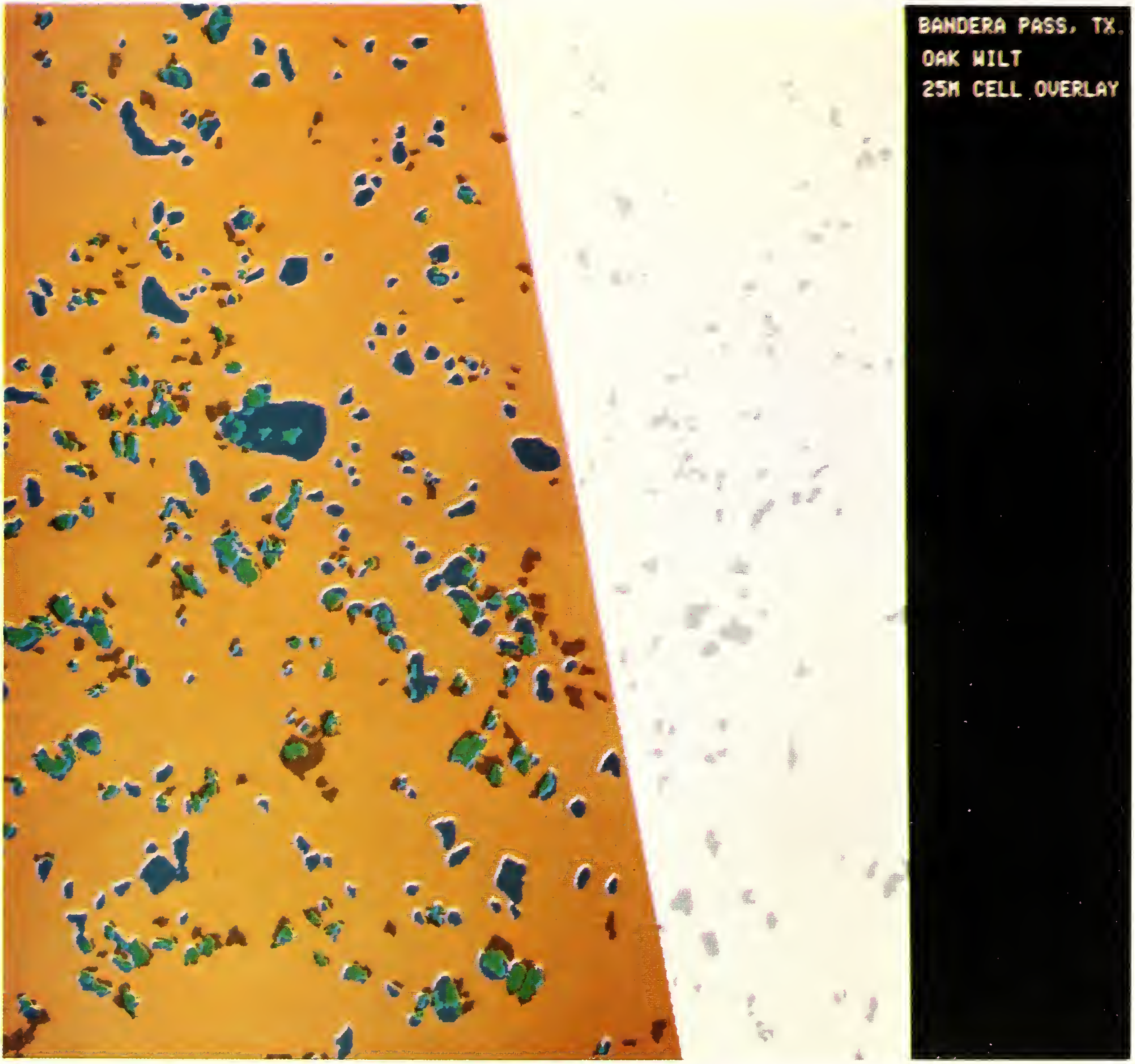

Figure 7 - REMIDAS color display of the Bandera Pass 7½ minute quadrangle comparing classification of oak decline and mortality on 9-inch and panoramic CIR aerial photos; (1) green areas were classified on both 9-inch and panoramic photos; (2) blue areas were classified on 9-inch photos only; (3) red areas were classified on panoramic photos only; (4) orange background designates that portion of the quadrangle covered by the 9-inch photos; (5) grey polygons are areas classified as oak decline and mortality on panoramic photos that fell beyond the 9-inch photo coverage; (6) white background designates that portion of the quadrangle outside the 9-inch photo coverage.

Table 2 - Changes in color of forest vegetation in central Texas relative to exposure on SO-131 color-IR film (NASA mission 83-081).

Vegetation Class	Color Relative to Exposure[1]		
	Underexposed	Optimum	Overexposed
Living hardwood (Deciduous and evergreen)	251 d.p. pink 258 m.p. red 259 d.p. red[2]	251 d.p. pink[2] 258 m.p. red[2] 259 d.p. red	258 m.p. red 261 l.g.p. red[2] 262 g.p. red [2]
Ashe juniper	215 g. violet	215 g. violet	185 p. blue 186 g. blue
Dead or declining hardwoods	186 g. blue	185 p. blue 191 b. grey	185 p. blue 190 l.b. grey

[1] Color designations are from color chips calibrated to National Bureau of Standards ISCC-NBS color designations which appear in Smith and Anson (1968)

[2] Denotes predominant colors.

working with panoramic photos, often drew one or more small polygons within the area classified by the interpreters working with the 9-inch photos (Fig. 7). Re-examination of the photos indicates that, at least in some instances, photo interpreters working with the larger scale 9-inch photos saw and classified areas of trees in the early stages of decline (thin crowns, portions of crowns dead) which were not visible on the smaller scale panoramic photos.

Approximately half of the polygons identified as tree decline and mortality only on the panoramic photography were, in fact, small areas of decline and mortality not visible on the 9-inch photos. This indicates that symptoms of decline and mortality may not have developed in these areas until after August 1982, the date of the 9-inch photos.

Another source of disagreement was a classic commission error; photo interpreters working with the panoramic aerial photos initially classified some brush piles as areas of tree decline and mortality. Area ranchers convert low grade juniper and hardwoods to range land by cutting and piling trees. On the panoramic photos, the brush piles appear similar in color and form to groups of dead and dying trees. However, an experienced photo interpreter, familiar with local conditions, can readily separate brush piles from standing trees by the amount of shadow they cast and the fact they are more or less evenly distributed throughout an area. Viewing the panoramic photography in stereo would have also increased photo interpreters ability to discriminate between brush piles and groups of dead trees.

Table 3 - Area of dead and declining oaks classified on both frame and panoramic photos, frame photos only and panoramic photos only, south central Texas.

7-1/2 Minute Map	Area of Dead and Declining Oaks (Acres)			
	Area Classified On Both Films	9-Inch Photos Only	Panoramic Photos Only	Total Area Classified
Flight Line E-F, Kerrville/Bandera, Texas				
Bandera	250	382	541	1,173
Bandera Pass	909	1,806	1,311	4,026
Center Point	879	2,390	533	3,802
Fall Creek	605	1,407	596	2,608
Kerrville	310	1,399	586	2,295
Legion	84	241	211	536
Rock Cliff Res.	58	267	68	393
All Maps - E-F	3,095	7,892	3,846	14,833
Flight Line G-H, Austin, Texas				
Austin West	23	96	232	351
Jollyville	110	350	320	780
Pflugerville	84	435	79	598
All Maps - G-H	217	881	631	1,729
Entire Target Area	3,312	8,773	4,477	16,562

Table 4 - Proportion of area of dead and declining oaks classified on both frame and panoramic photos, frame photos only and panoramic photos only, south central Texas.

7-1/2 Minute Map	Proportion of Area of Dead & Declining Oaks		
	Classified On Both Films	9-Inch Photos Only	Panoramic Photos Only
Flight Line E-F, Kerrville/Bandera, Texas			
Bandera	21.3	32.5	46.1
Bandera Pass	22.6	44.9	32.6
Center Point	23.1	62.9	14.0
Fall Creek	23.2	53.9	22.8
Kerrville	13.5	61.0	25.5
Legion	15.7	45.0	39.3
Rock Cliff Res.	14.7	67.9	17.3
All Maps - E-F	20.9	53.2	25.9
Flight Line G-H, Austin, Texas			
Austin West	6.6	27.3	66.1
Jollyville	6.5	44.9	41.0
Pflugerville	14.0	72.7	13.2
All Maps - G-H	12.5	50.9	36.6
Entire Target Area	20.0	53.0	27.0

Minor sources of disagreement resulted from errors in transferring polygons of oak decline and mortality from the 9-inch photos to their corresponding map base. One instance of a photo interpreter inadvertently transferring the boundaries of a small pond to the 9-inch map base was discovered. In addition, several cases of a photo interpreter classifying stands of mesquite as oak decline and mortality on the 9-inch film occurred. These were later corrected but not clearly labeled and were inadvertently digitized into the 9-inch data base as areas of decline and mortality.

DISCUSSION AND CONCLUSIONS

In a classic analysis of this type, where a new technique is compared to an "old established technique", the old technique is assumed to be "ground truth". Therefore, any areas of disagreement in classification would be counted against the new technique, in this case the panoramic aerial photography, as omission and commission errors.

This approach is inappropriate for this evaluation for several reasons. First, the 9-inch data contains errors which were not discovered until the two data sets were compared. One of the errors discovered was in the transfer of polygons from 9-inch aerial photos to their corresponding map base. The actual number of misplaced polygons was not determined; however, each misplaced polygon on the 9-inch map base would count as both an omission and commission error if the polygon was detected and transferred correctly on the panoramic photos.

Another source of disagreement is the fact that a 9-month period occurred between acquisition of the 9-inch and panoramic photos. While most of this occurred during the dormant winter months, apparently some new areas of mortality developed and were visible on the panoramic photos which did not appear on the 9-inch photos.

The area of decline and mortality classified on 9-inch photos and not on panoramic photos is attributed to the fact that the smaller scale panoramic photos were unable to resolve early signs of stress and decline. The reduced ability to detect subtle signs of stress and decline on photos of smaller scale is well documented (Murtha 1983). This is especially true at 40° from nadir where the scale is smaller still and the angle of view makes stressed vegetation more difficult to detect. Therefore, these results are not surprising.

This evaluation indicates that small scale panoramic aerial photography is a promising tool for detecting groups of oak mortality in central Texas. It is not as reliable as larger scale aerial photography for mapping early signs of stress and decline. Increased photo interpreter experience and familiarity with ground conditions should significantly reduce the incidence of commission error associated with this evaluation. In addition, viewing the film in stereo rather than monoscopically may increase interpretation accuracy.

The results of this work do not suggest that panoramic aerial photography is a promising tool for detecting oak wilt in the timber producing oak forests of the eastern United States. Oak wilt centers are typically small in these areas and are consequently more difficult to detect.

The use of a geographic information system, such as the MOSS component of REMIDAS, is an effective way to compare interpretation of two photo types. This approach could also be used to compare the work of individual photo interpreters, to evaluate the effect of the season of the year, monitor pest status change, and to compare classification schemes where degrees of damage (i.e., light, moderate or heavy) are used.

ACKNOWLEDGMENTS

We wish to thank the following individuals for their participation in this work:

The U-2 Support Group, NASA Ames Research Center, Moffett Field, California, for photo acquisition and film processing.

Paul Ishikawa, on contract to USDA Forest Service, Nationwide Forestry Application Program, Houston, Texas; Dale Starkey and James G.D. Ward, USDA Forest Service, Southern Region, Forest Pest Management, Pineville, Louisiana, and Doraville, Georgia, respectively, for assisting with photo interpretation and map transfer.

Dr. Robert Maggio, Texas A&M University for briefing photo interpreters and making the 9-inch photos available for study.

Dave Wolf, USDA Forest Service, Rocky Mountain Region, Denver, Colorado, for preparation of PANGRID equal area grids.

William H. Clerke, USDA Forest Service, Southern Region, Atlanta, Georgia, for technical assistance in use of REMIDAS.

James Bell and F.P. Weber, USDA Forest Service, Nationwide Forestry Application Program, Houston, Texas, for making arrangements for facilities and equipment during the photo interpretation phase.

Robert Maggio and David N. Appel, Texas A&M University; and William H. Clerke, H.D. Brown and H.V. Toko, USDA Forest Service, Southern Region, Atlanta, Georgia, for manuscript review.

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